Building the AMSAT Cubesat Simulator

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About me

Having watched the Apollo 11 moon landing on TV, I decided I wanted to work for NASA. I applied for an opening, took 5 qualifying exams and was on my way To Gillmore Creek, a satellite tracking facility near Fairbanks, AK. W7DGP became KL7HGR. Dream job? Oh yeah! 1969 to 1972

My first job at Gillmore: 16-yagi array known as SATAN or Satellite Tracking and Navigation. Freq range: 136 – 137 Mhz.

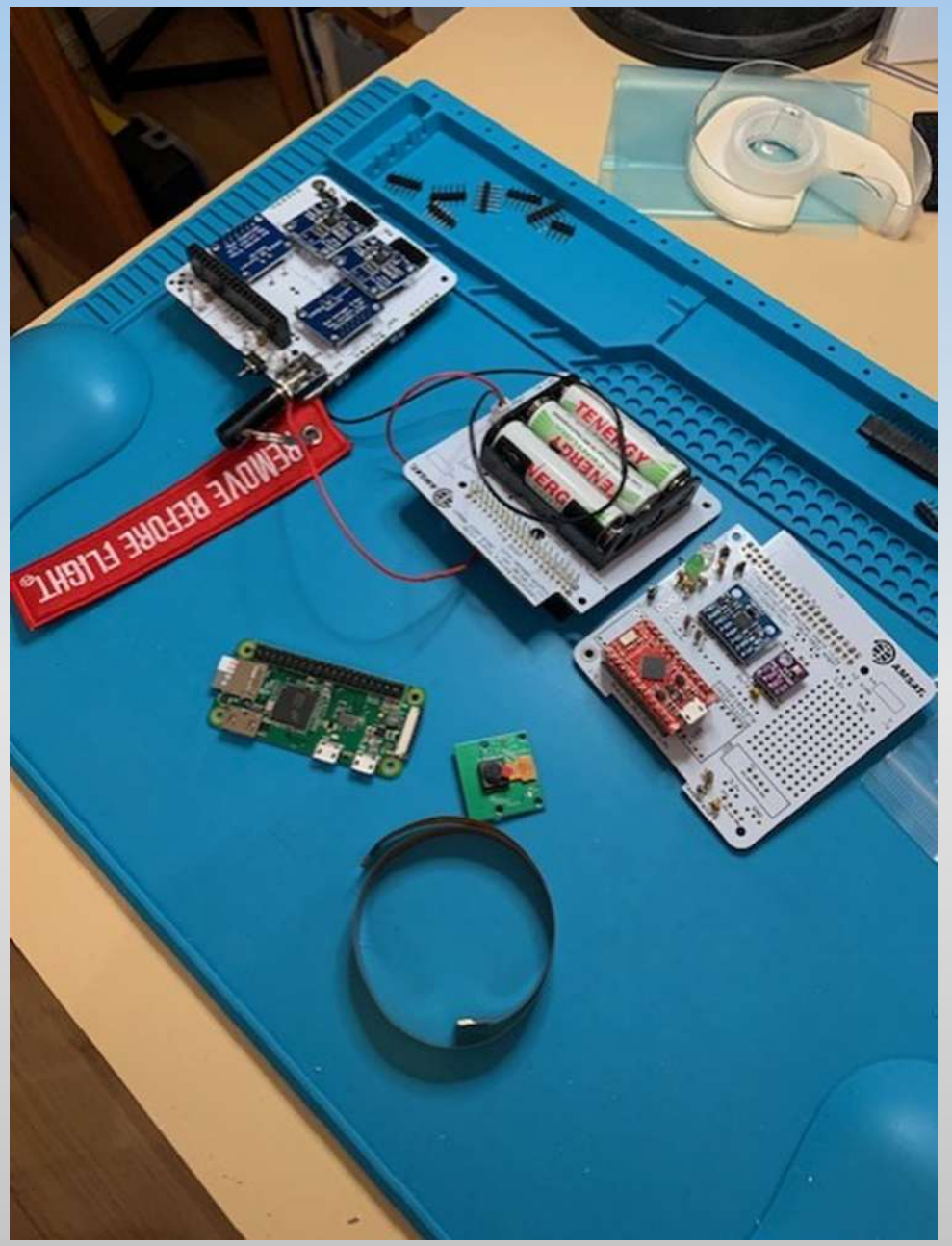
So, what did I track using that big yagi array?

There were over **40** sats that downlinked telemetry on the VHF band of 136 – 137 Mhz. For example, there was the GEOS series, ISIS series and IMP-E. These are scientific data sats.

- Interplanetary Monitoring Platform, IMP
- Weighed over 230 lb! Not a cubesat!
- Data collection centered around particle radiation from the sun and the moon's gravity field. All of this was in support of the Apollo program.
- It had a very elliptical orbit and studied cislunar space prior to each Apollo launch.

Let’s make our own satellite:
The AMSAT Cubesat Simulator

Aug 2022



A week later, mostly done soldering in parts

A complete bill of materials, B.O.M is provided by AMSAT:

A1 | fx lar

	A	B	C	D	E	F	G	H	I	J
1	lar		**Bill of Materials for CubeSatSim v2.0 PCBs (Blue PCBs)**							http:/
2										
3			Note: if you have the beta v1.3.2 PCBs, here is the BOM:				https://docs.google.com/spreadsheets/d/1Ta5UaJcinGozcheROrkfwXdGSDUZrXvQ			
4			Note: if you have the v1.2 PCBs (white PCBs), here is the BOM:				https://docs.google.com/spreadsheets/d/1tC7p3Lec_wPqt_oGHnX3Rg3dV0P5UQc			
5										
6			*If you have a Google account, you can make your own copy of this spreadsheet by going under File then Make a Copy*							
7			*The colored rows which begin with "Alt" indicate alternatives. Uncheck the (a) choice to get the (b) choice*							
8										
9										
10			Main Board		https://github.com/alanbjohnston/CubeSatSim/blob/567ccb5032782358cfb48306dd1e93bf72ee8e5a/ha					
11										
12	☑	Ref	Item		Qty	Cost	Total	Source	Source URL	Alternate Source URL	Notes
13	☐		Pi Zero 2 with pre-soldered headers	☐	1	$16.00	$0.00	Various	https://rpilocator.com/?coun		You c
14	☐		Pico WH (with pre-soldered headers)	☐	1	$7.00	$0.00	Various	https://octopart.com/search'		You c
15	☐		Alt 4a: Main Board PCB with SMT componen	☑	1	$15.00	$15.00	AMSAT	https://www.amsat.org/prc		The A
16	☐		Alt 4b: Main Board PCB without SMT compo	☐	1	$49.20	$0.00	Various			See SM
17	☐		USB-C cable and power plug		1	$4.88	$4.88	Amazon	https://www.amazon.com/		If you
18	☐		16GB micro SD Card with cubesatsim im		1	$9.82	$9.82	Amazon	https://www.amazon.com/	https://www.amsat.org/prc	Any 1

“In these steps, you will start building…..”

1. Main Board 1

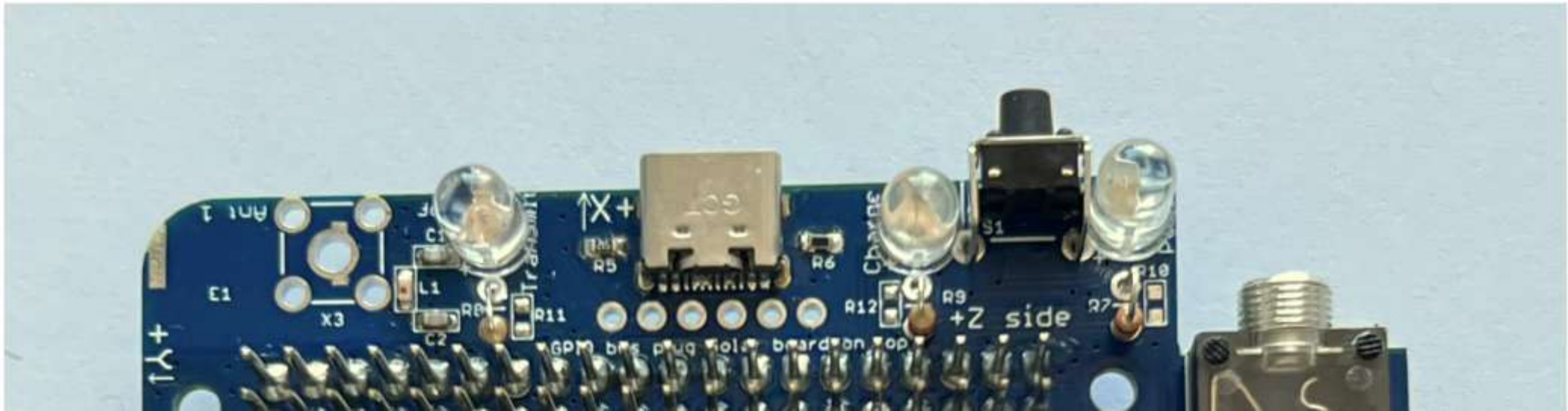
Alan Johnston edited this page on Jul 31 · 52 revisions

If the images on this page fail to load, you can download a PDF of the page here.

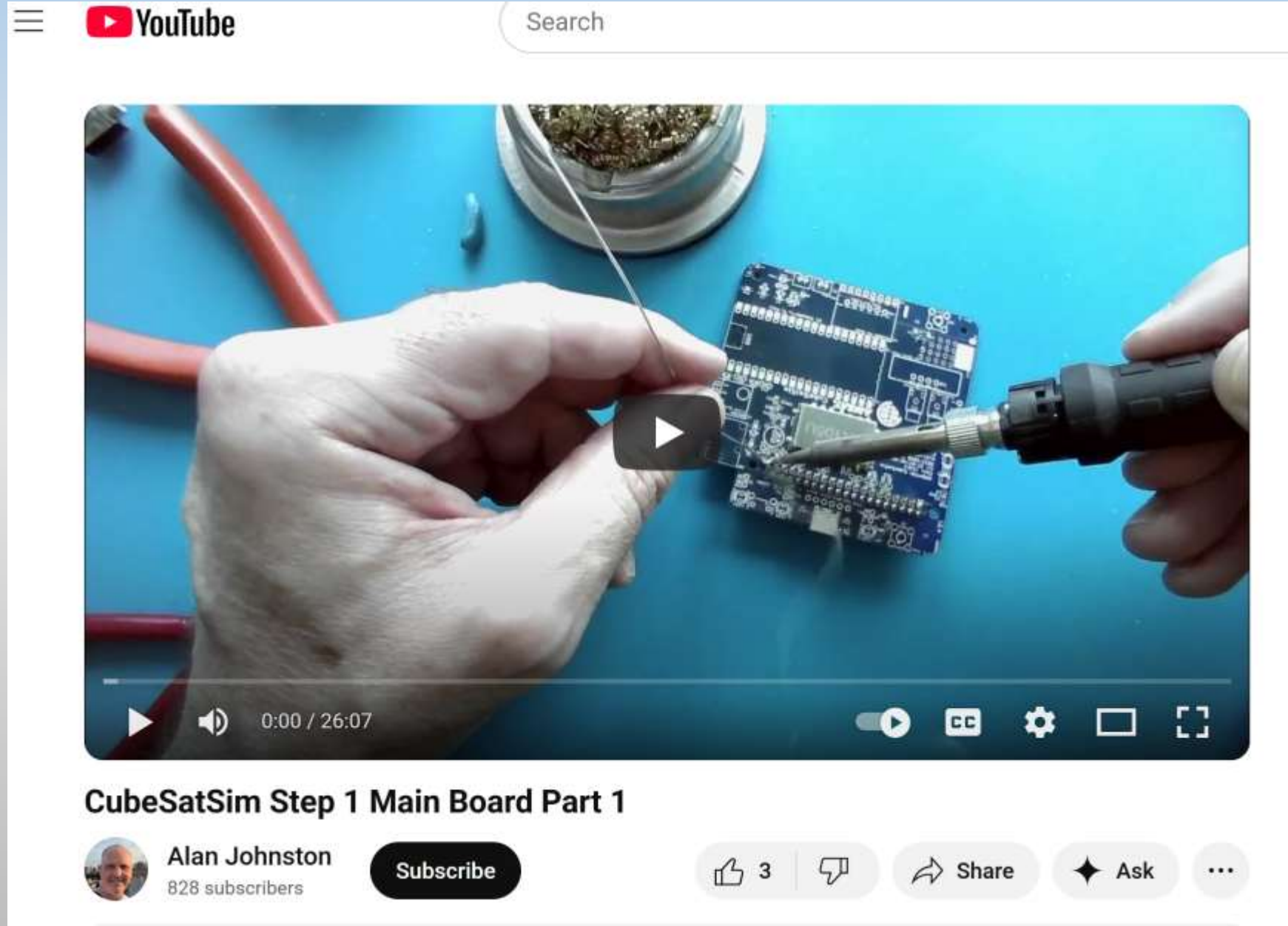
1. CubeSatSim Main Board Assembly Part 1

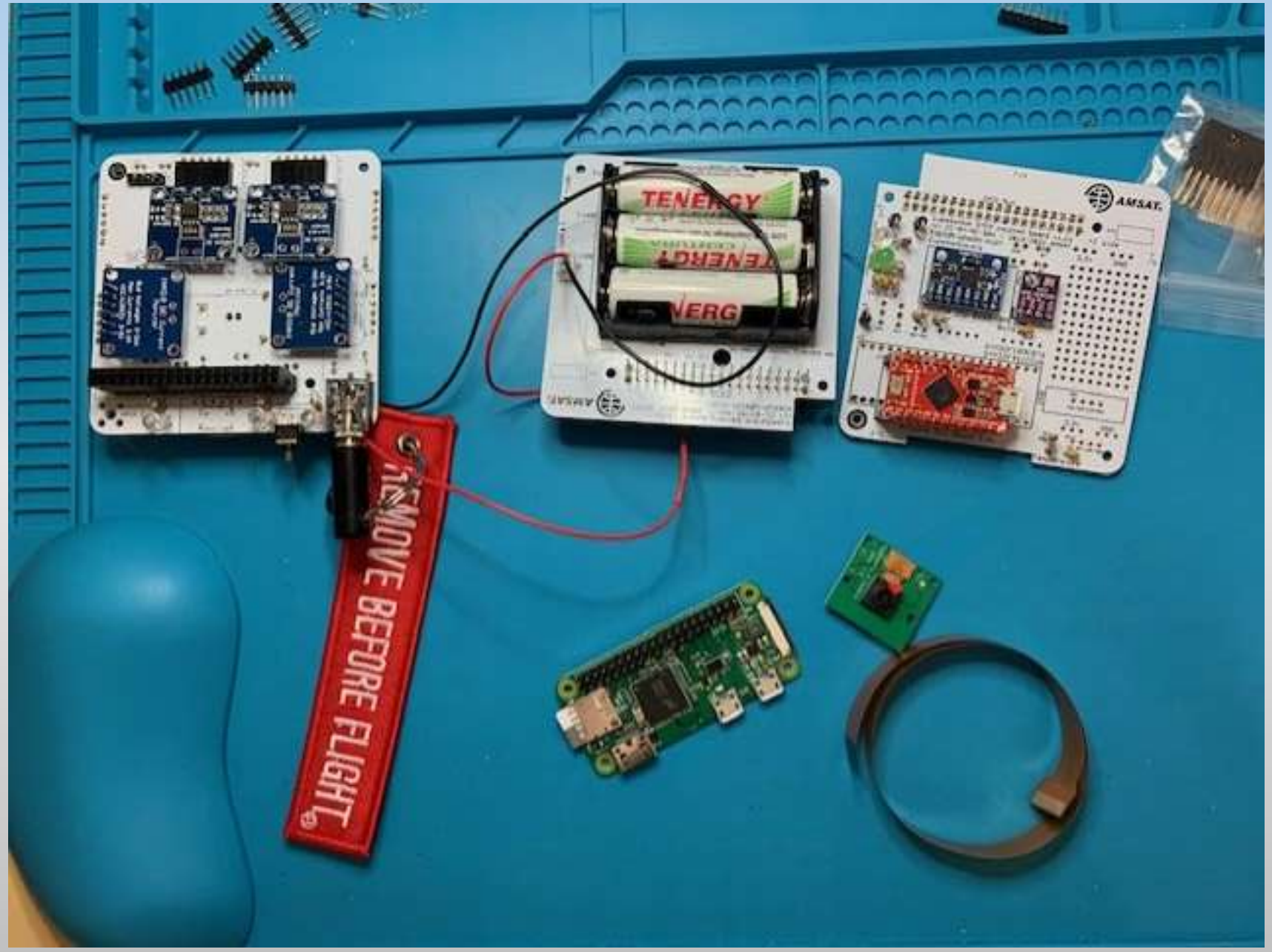
In these steps, you will start building your Main Board.

These steps are used to build a v2.0 CubeSatSim shown here:



Step by step videos

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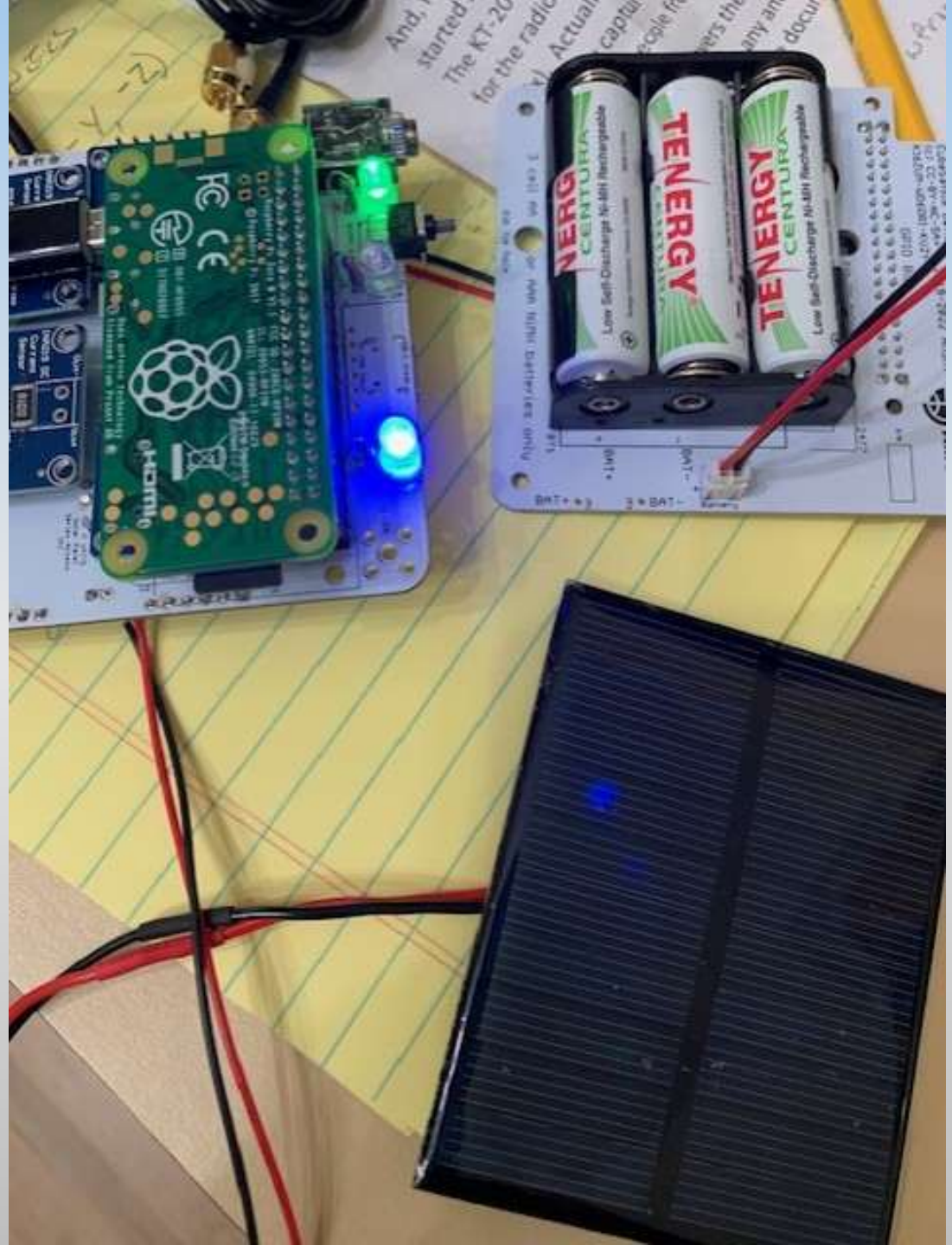
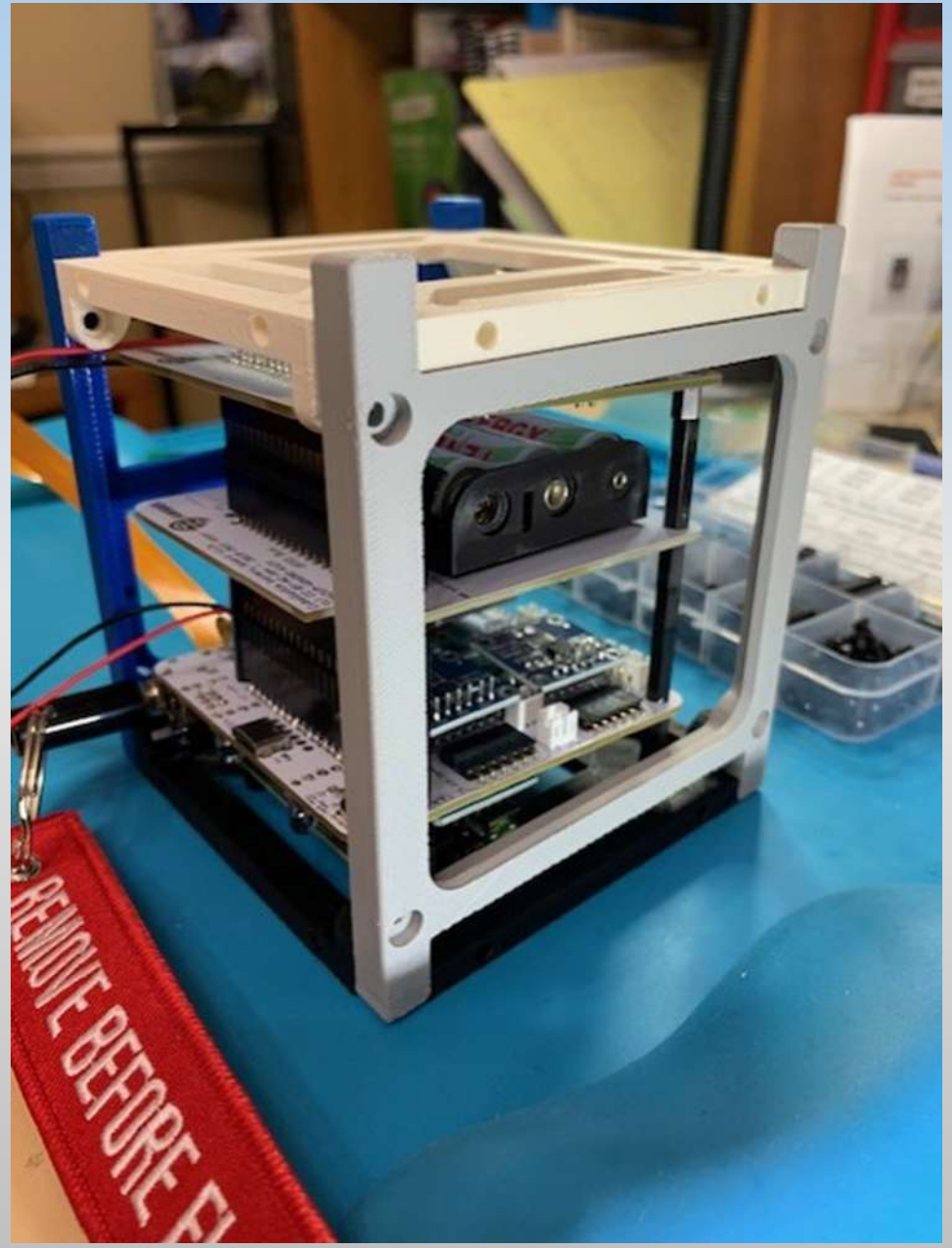
REMOVE BEFORE FLIGHT

Intermediate testing. Here, I plugged in one solar panel and tested the software and each voltage/current sensor.

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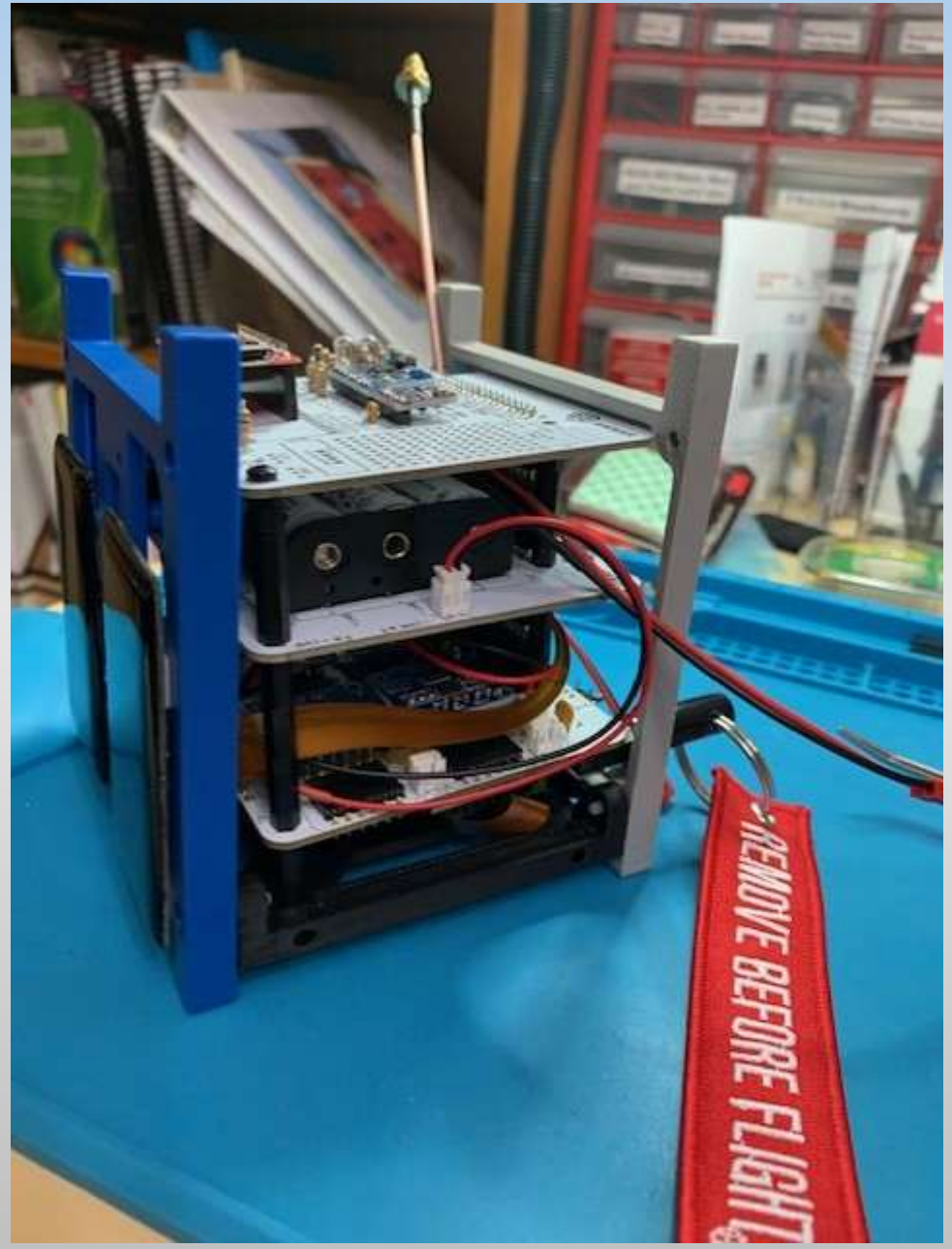
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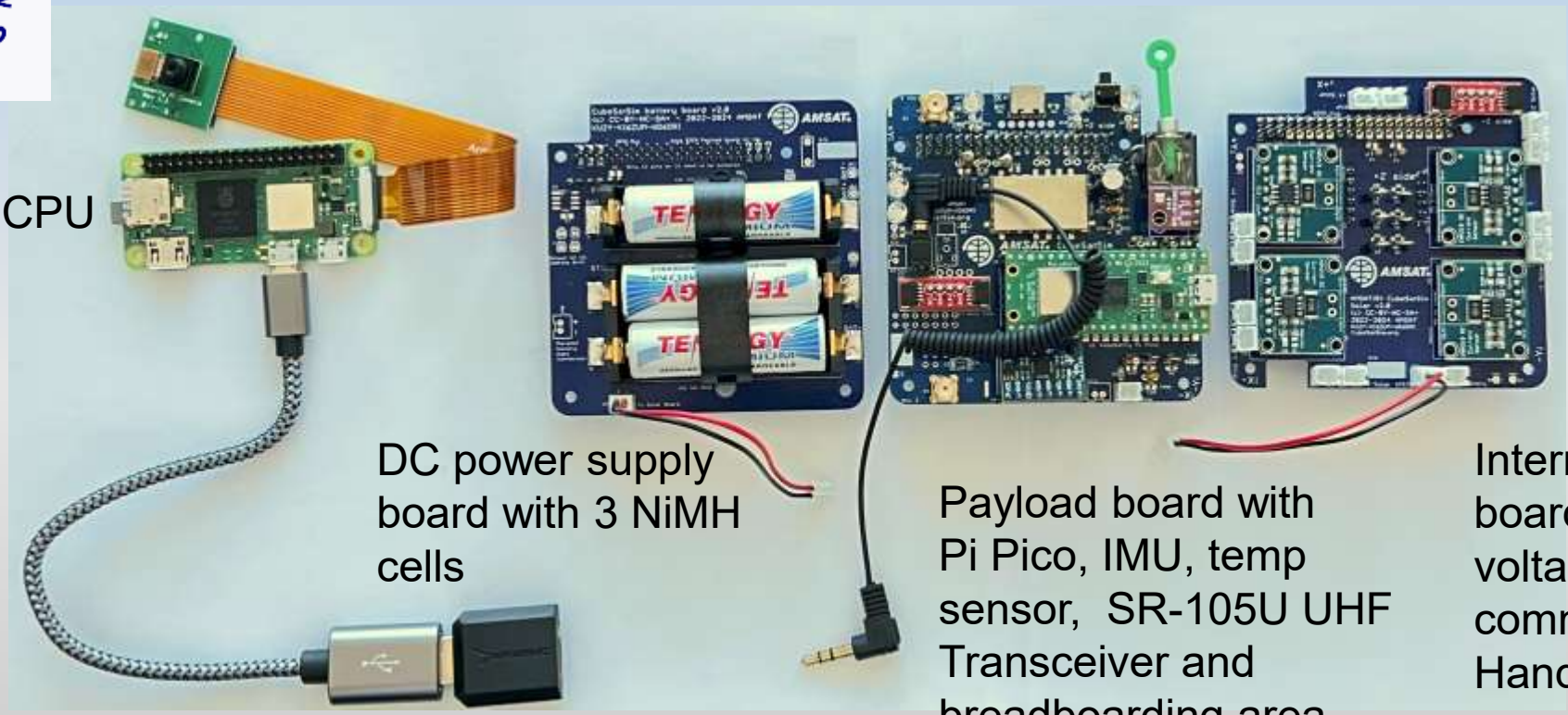
My 2nd Cubesat: The AMSAT Cubesat Simulator 2.1

https://cubesatsim.org



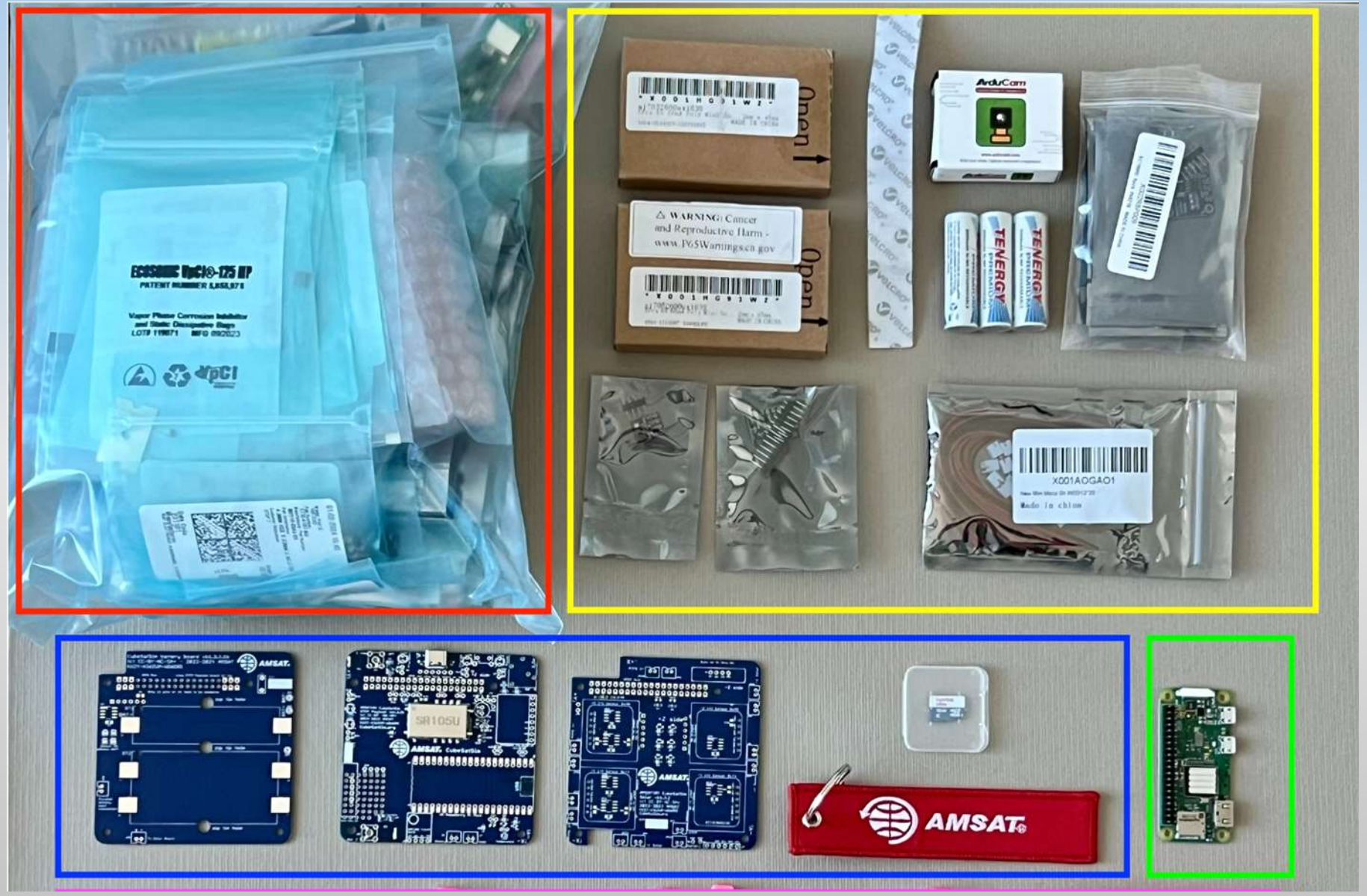
Pi Zero 2 W main CPU with Pi Camera

DC power supply board with 3 NiMH cells

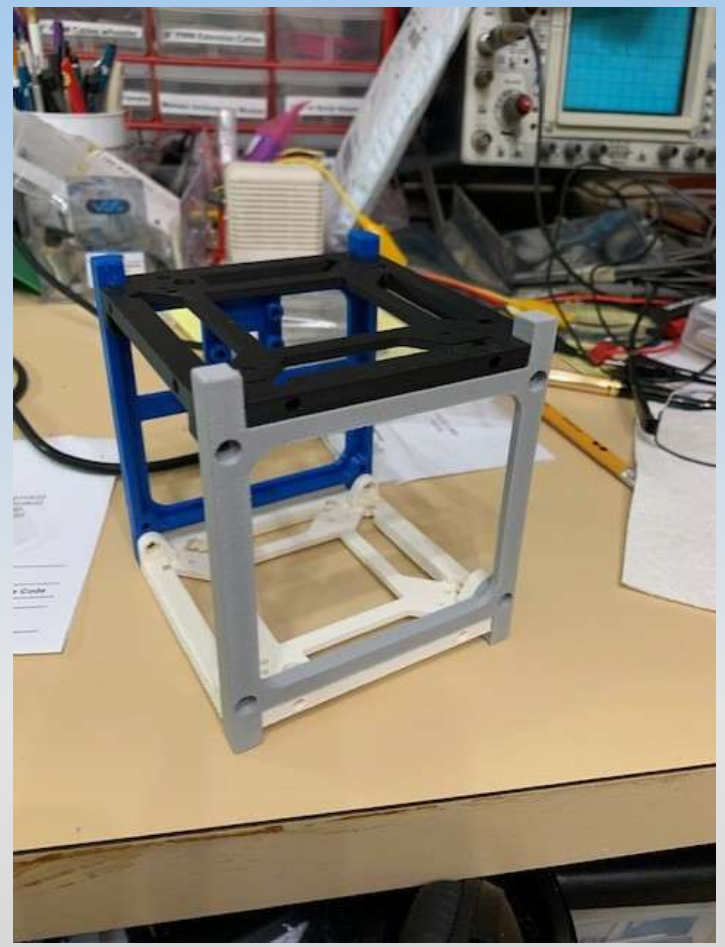
Payload board with Pi Pico, IMU, temp sensor, SR-105U UHF Transceiver and breadboarding area

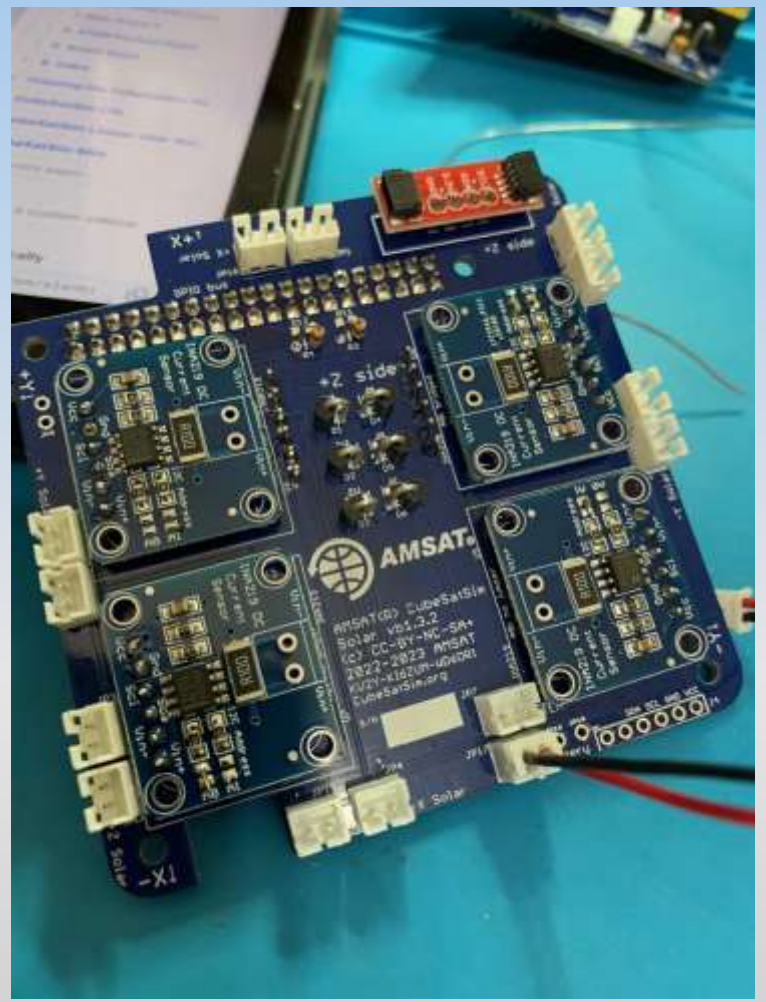
Internal housekeeping board with current and voltage sensors + command and data Handling, Pi Zero 2 W

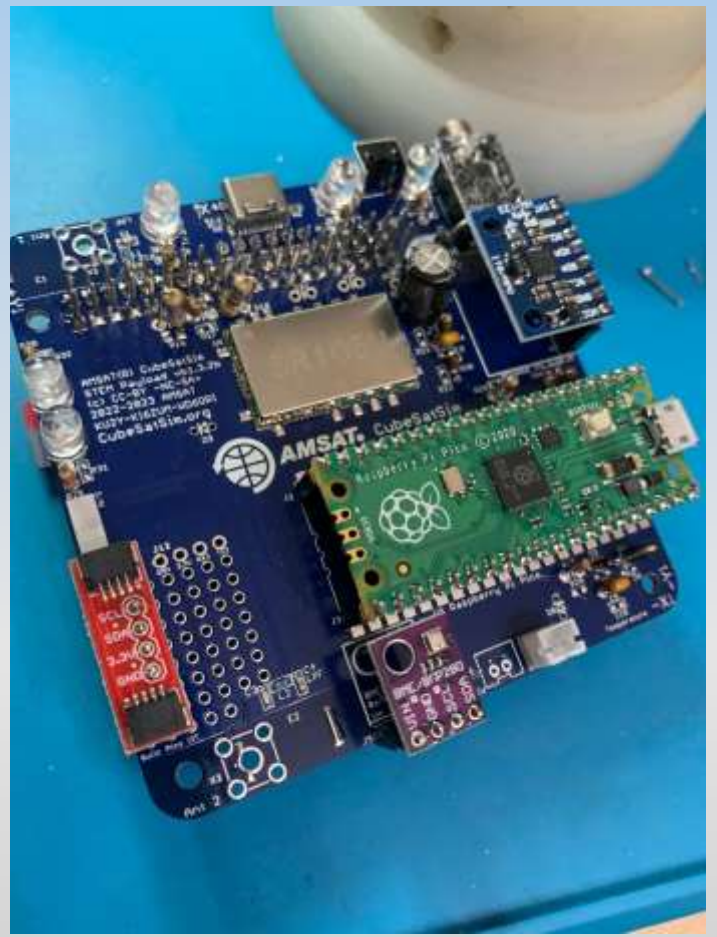
Sound card used to decode tone commands


Open
Open
ArduCam
TENERGY
X001AOGAO1
AMSAT
SR105U
AMSAT

First step: send the CAD files to a 3-D printer. Select plastic type and colors. I wanted each surface a different color. On the left is how they arrived and to the right, they are assembled. CAD files supplied by AMSAT. The 3 boards will fit inside



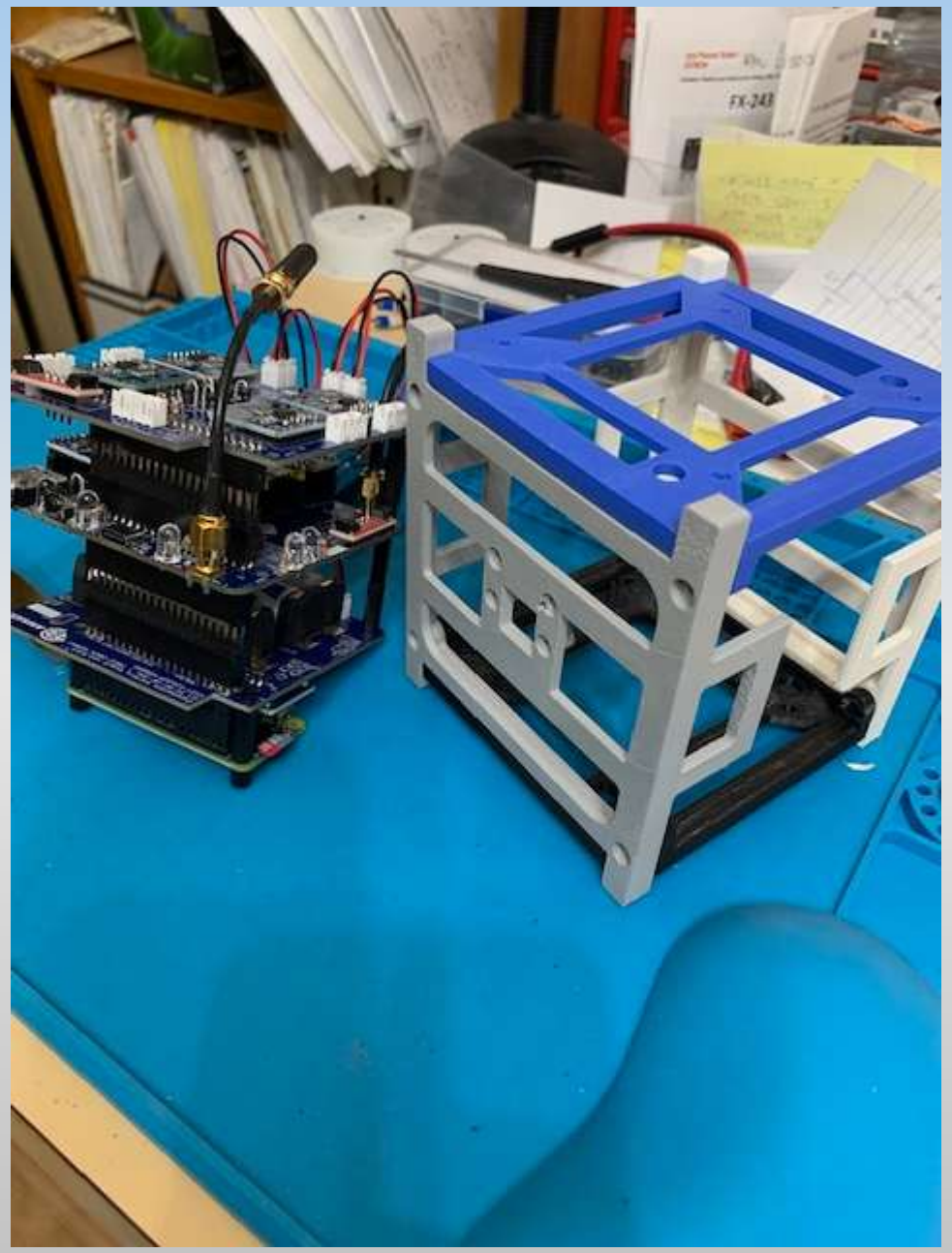


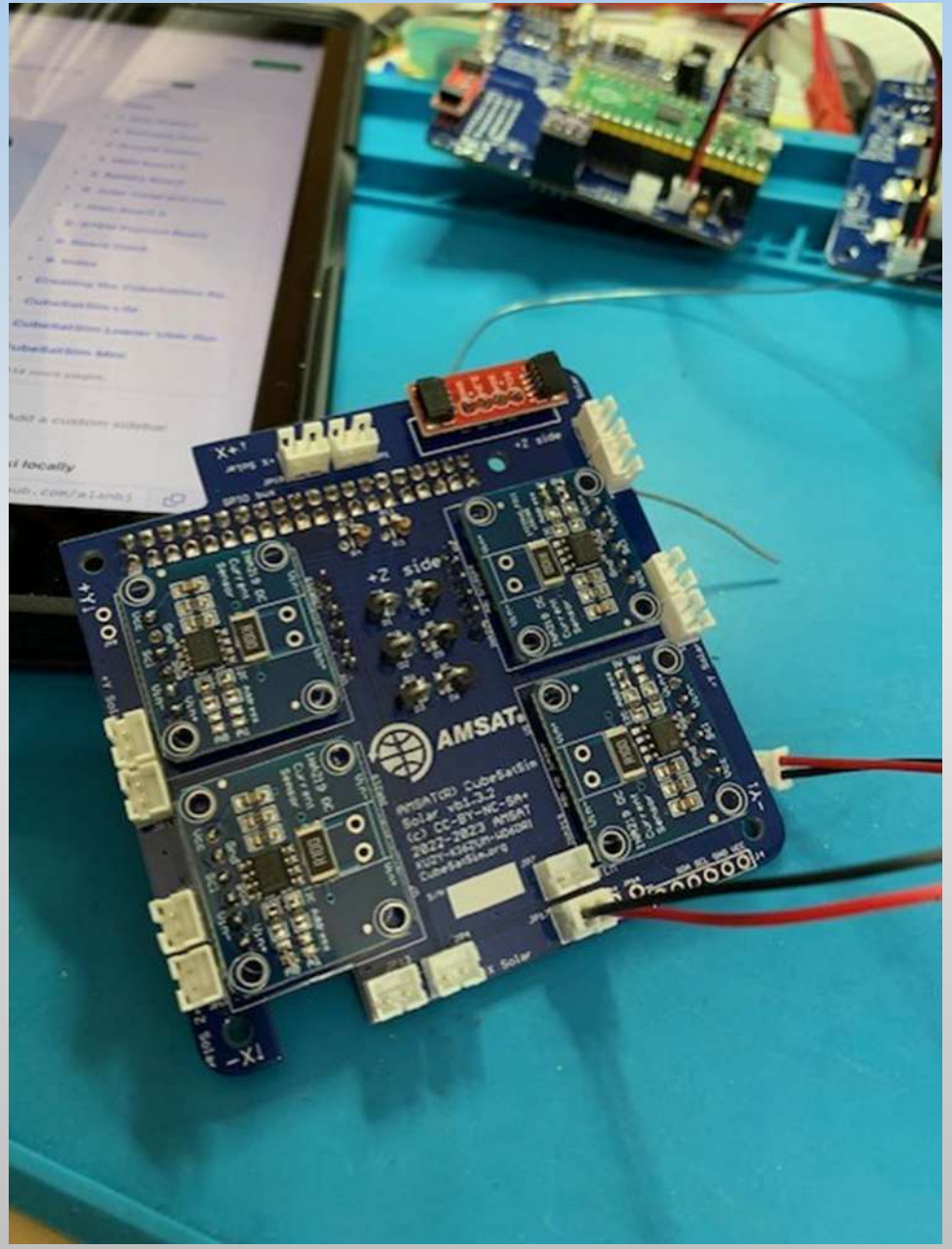


Here are the completed V2 boards. Next, assemble the stack and fit into the frame assembly. This cubesat sim worked the first time. Next was adding Command and Control.

Many thanks to Alan Johnston, KU2Y, AMSAT VP of Educational Relations.

Feb 2024




AMSAT

I set up a basic ground station using the RTL-SDR dongle with the accompanying antenna plus FoxTelem on my laptop. Order the dongle with the antenna. FoxTelem is a free download. Use dongle v3 only.

The best ground station system: Fox In A Box, FIAB

burnsfisher.com/AMSAT/FoxInABox/

- **FoxTelem** - decodes telemetry from AMSAT CubeSats
- **OpenWebRX+** - a Web SDR
- **QSSTV** - for decoding SSTV images.
- **Direwolf** - for decoding APRS packets.
- **SDR++** - an open source general purpose SDR
- **CubicSDR** - another general purpose SDR
- **FunCube Telem** - a new experimental decoder for the CubeSatSim FunCube mode 7
- **RTL-TCP** - an application for accessing an RTL-SDR dongle across a network.
- **Gpredict** and **G0KLA** trackers
- **Pacsat**

Not to be confused with the Fox in a Box Escape Room

AMATEUR RADIO IN SPACE
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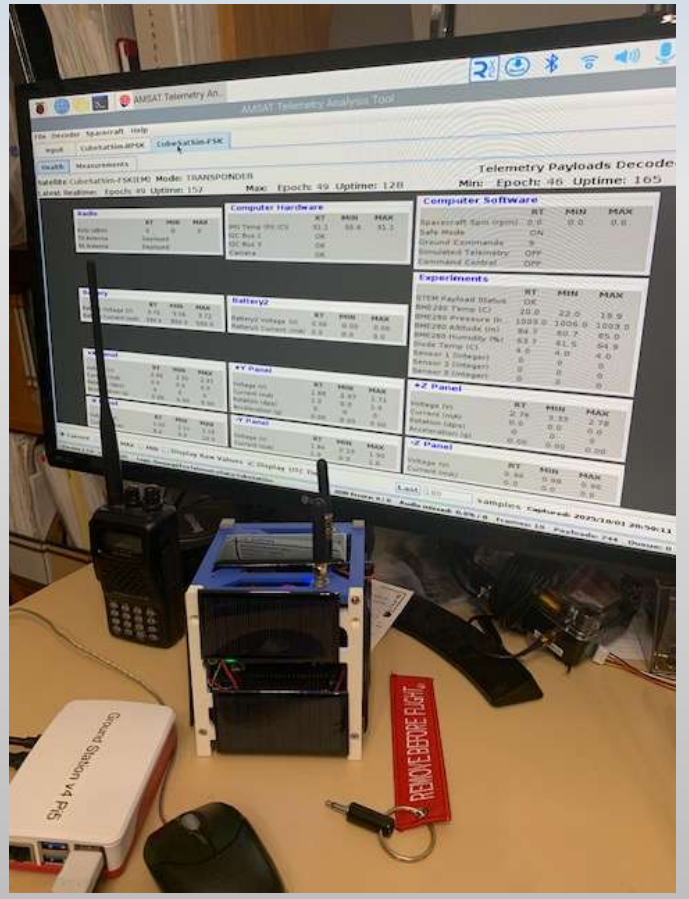
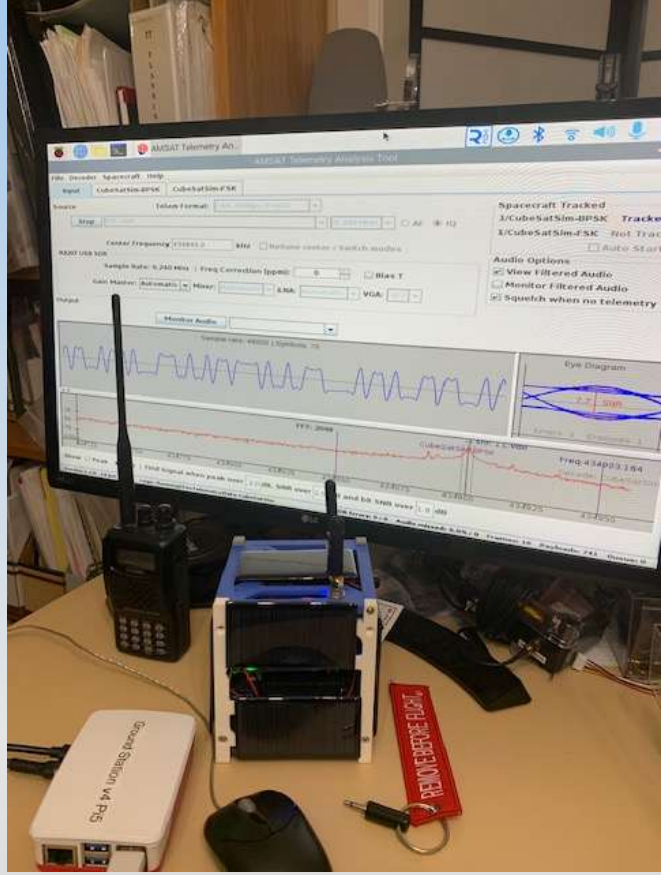

AMSAT Telemetry Analysis Tool
Telemetry Payloads Decode
Computer Hardware
Computer Software
Experiments
Ground Station v4 PG
REMOVE BEFORE FLIGHT


AMSAT Telemetry Analysis Tool
Spacecraft Tracked
Audio Options
Ground Station v4 PG
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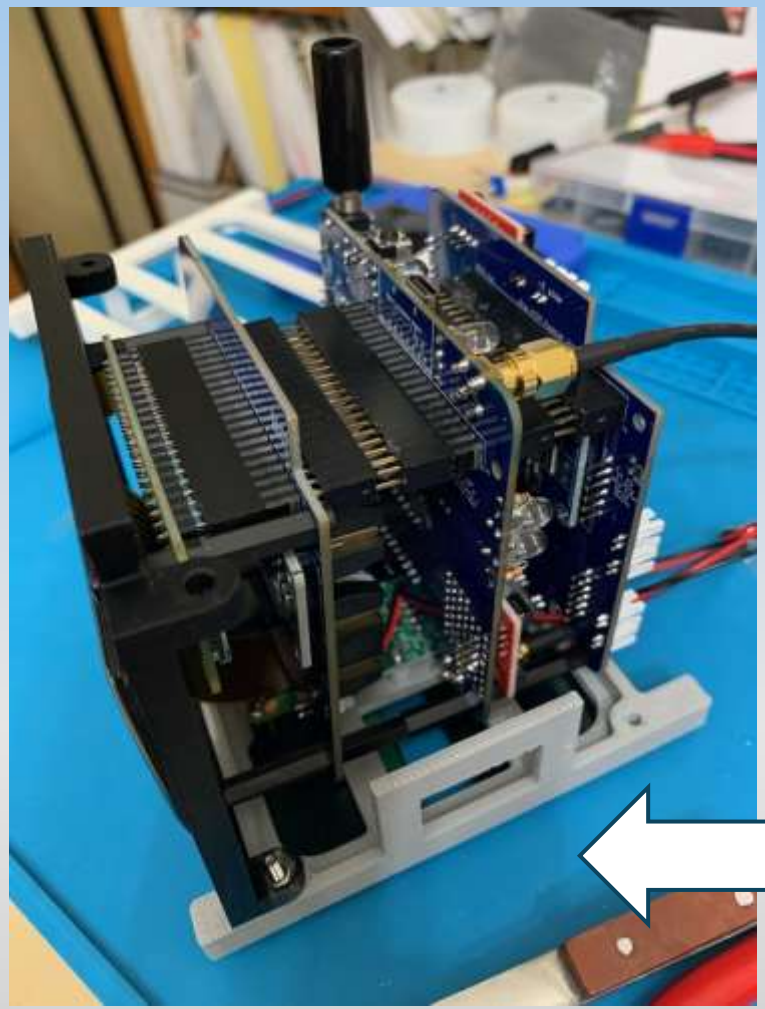
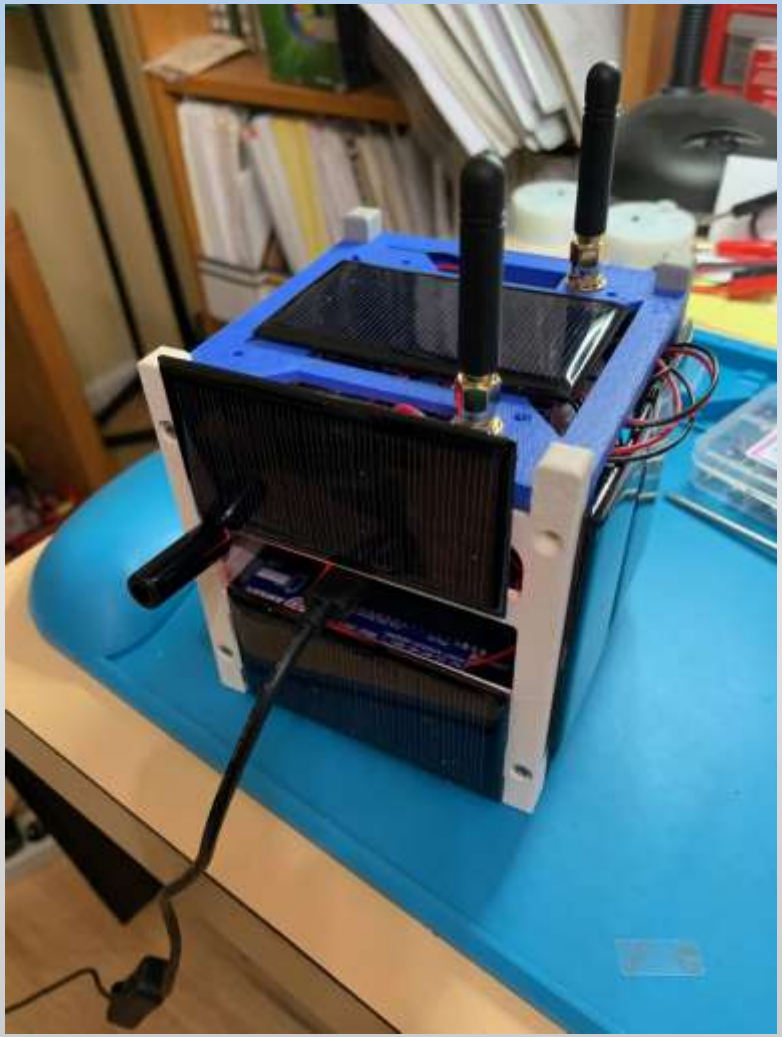
Software and Final Assembly



The Cubesat Sim software is supplied either by purchasing an SD card from AMSAT or the AMSAT github site. For version 1, I purchased the SD card. It came already formatted with the Raspberry PI config plus the Cubesat Sim software. Later I upgraded the software with updates from the Github site. For ver 2, I “cloned” the software from the Github site.

Here, I am fitting the board Stack to the frame pieces. This was the most difficult process. Double check that you’re using the correct header size!



The finished v2 CubeSatSim

Lessons learned – the Build and the Software

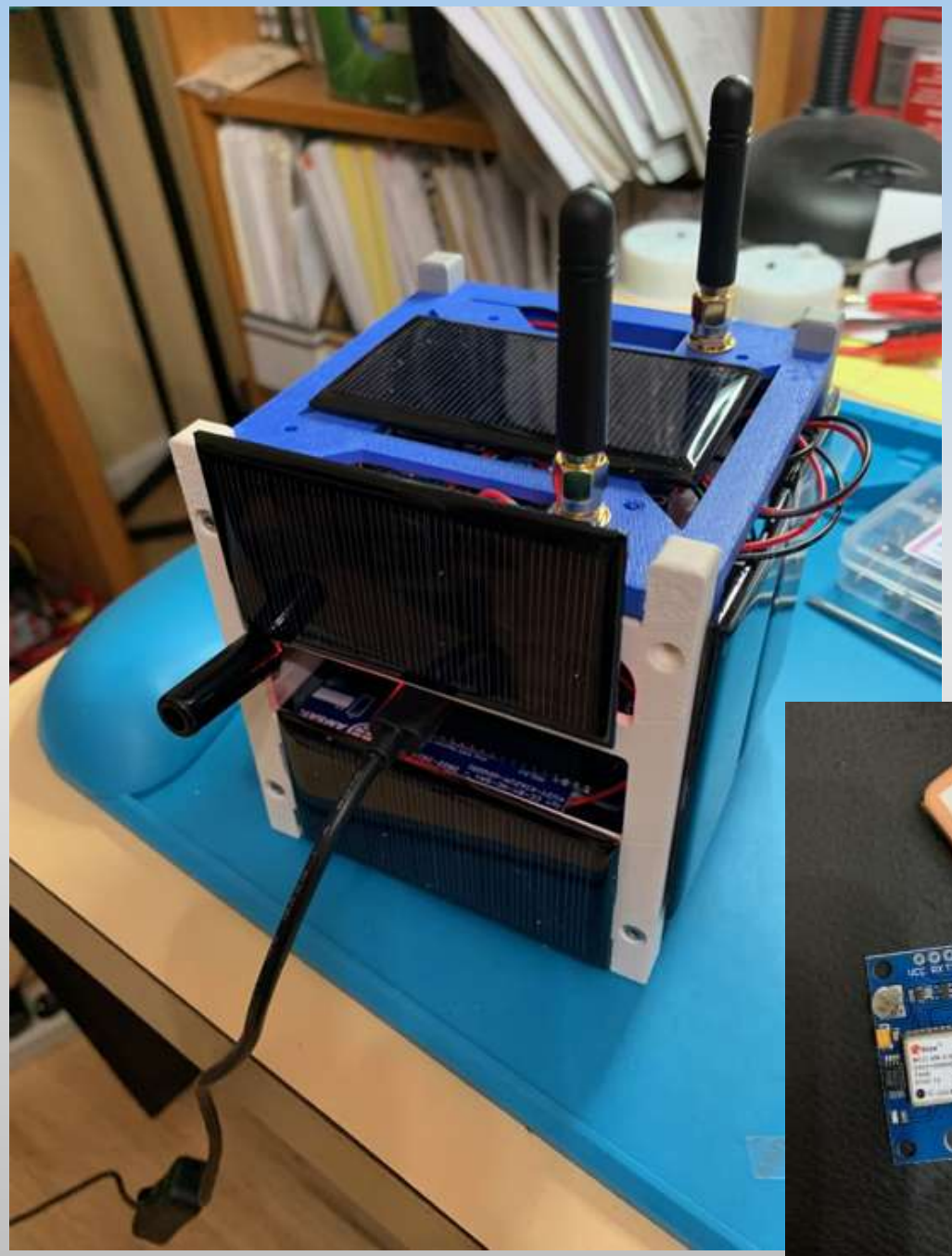
The build:

- *The B.O.M* supplied by AMSAT solves the parts sourcing problem with any home brew project. “Octopart” was totally new to me and I failed to take advantage.
- *The CAD* for the frame pieces is provided! I didn’t have a 3D printer so I located a service and the pieces arrived in a week.
- Lots of *intermediate testing* helped to identify bad or incorrectly delivered components. I made a few test fixtures using an Arduino. I2C is the data comm protocol of choice.
- *Quality soldering* is a key skill along with quality soldering equipment. I have years of experience and training (military and NASA) and I did my best work on the cubesat.
- Getting the *board stack to fit in the frame properly* was not easy! I had to order different spacers. Double check the stacking headers before soldering!
- *Modifying the build* on v2 was easy due to the BOM and step by step instructions: Pi Zero to Pi Zero 2, charging mod and sound card addition took an afternoon.

Lessons learned – the Build and the Software

The Software:

- *All software is provided* so it was welcome news that no programming is required
- While the software can be purchased from AMSAT on an SD card, all software is *available on the Github site*. Revisions are frequently available from AMSAT.
- *This was Raspberry Pi project #15* for me so I was comfortable with RPi development processes: SD Card imaging, selection of distro, the command line, power requirements, Wifi, and logging in (I use PuTTY). I used all those skills.
- *The frequent use of the command line* in the RPi login prompted me to set up /home/pi/.profile so I had PATH set up for the Config command.
- *FIAB or Fox in a Box* is awesome and runs on Pi 4 or 5. I use a Pi 5 and a large monitor with FIAB for my ultimate ground station. Everything you need is there.
- This was my first *RPi Pico*. It uses the Arduino IDE for flashing software. The step by step instructions for the Pico were easy to follow and worked.



Questions?

Future project: add
GPS to payload

llryan@msn.com

W7DGP, ok in QRZ.com